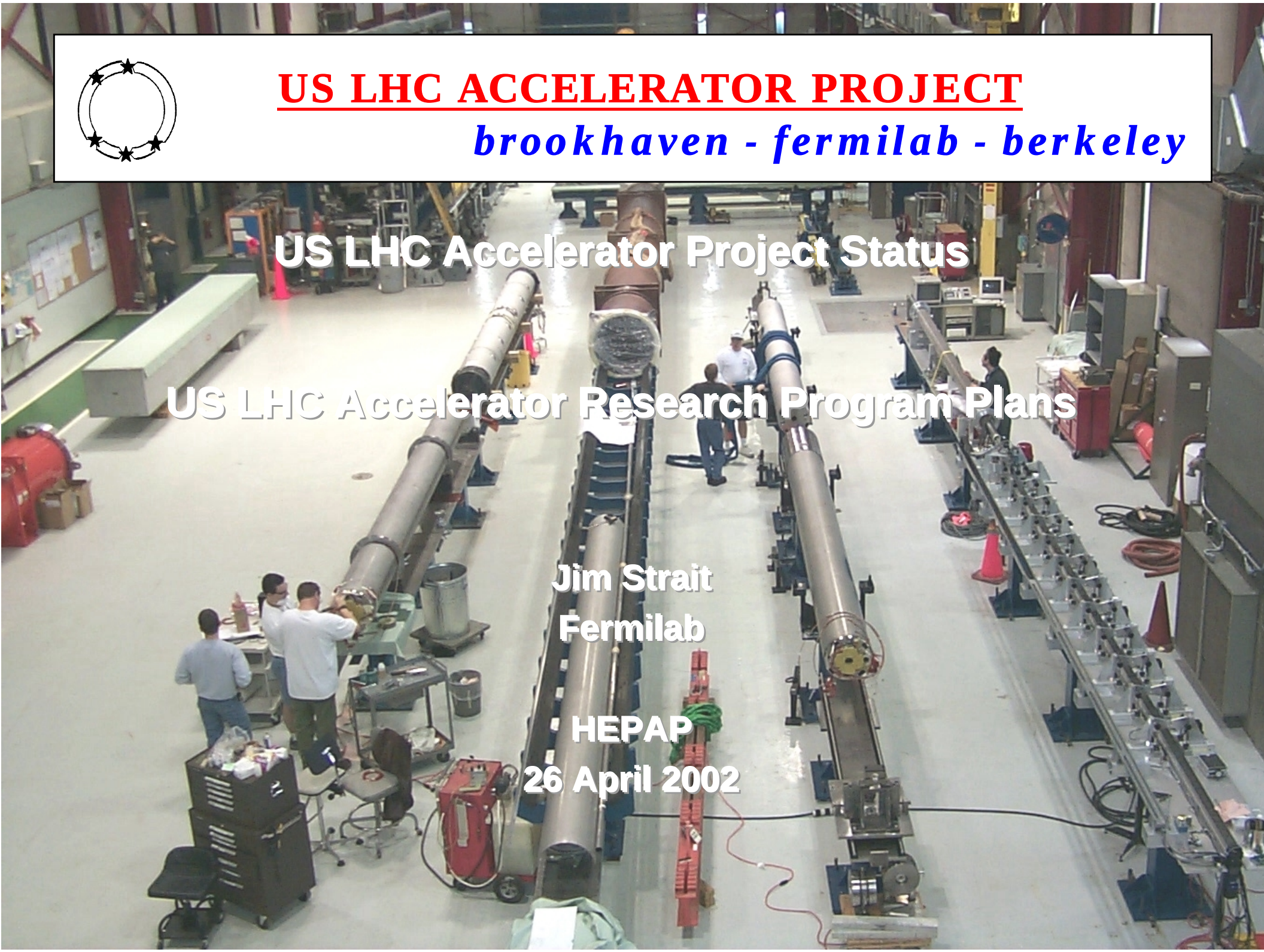


US LHC ACCELERATOR PROJECT

brookhaven - fermilab - berkeley

US LHC Accelerator Project Status

US LHC Accelerator Research Program Plans

Jim Strait
Fermilab

HEPAP
26 April 2002

US LHC Accelerator Project

IR Final Focus Systems: Points 1, 2, 5, 8

- –US-built quadrupoles (FNAL)
- –Japanese-built quadrupoles (KEK)
- –CERN-provided correctors
- –Cryostats for all quadrupole assemblies (FNAL)
- –US-built beam separation dipoles (BNL)
- –US-built IR feed boxes (LBNL)
- –US-built specialized absorbers (LBNL)

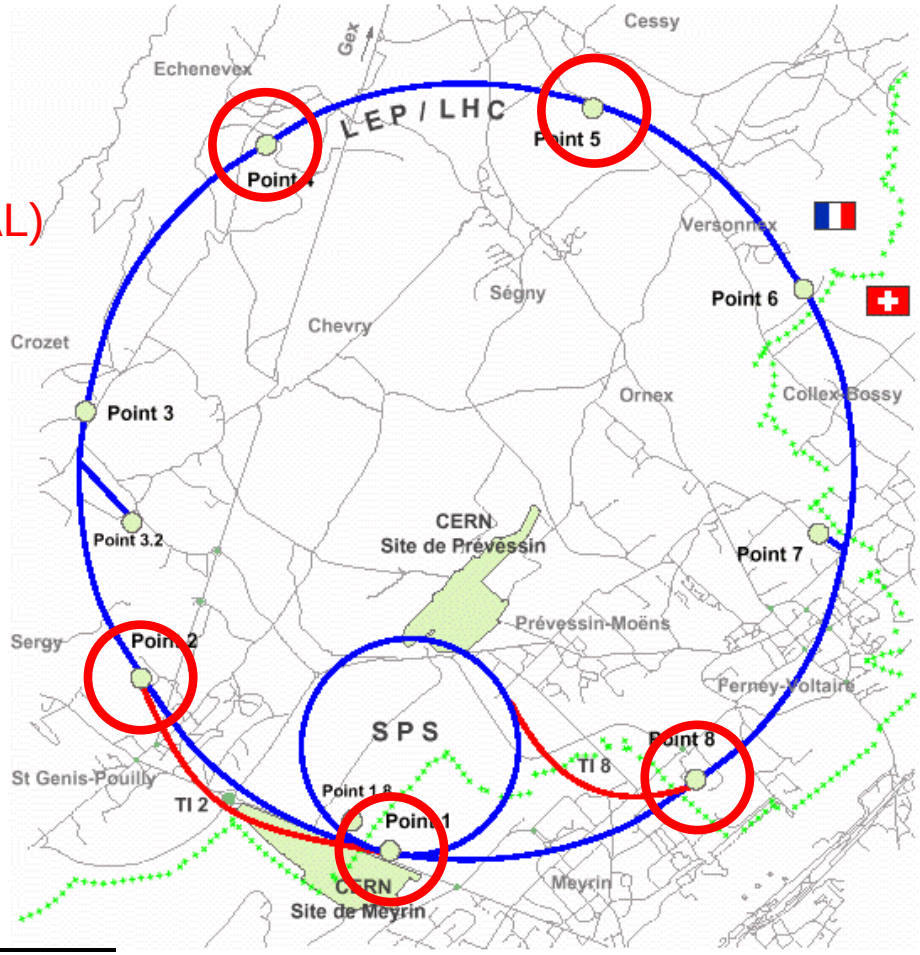
RF Region: Point 4

- –Beam separation dipoles (BNL)

Wire and Cable for Main Magnets:

- –Measurement of SC wire & cable (BNL)
- –Cable production support (LBNL)

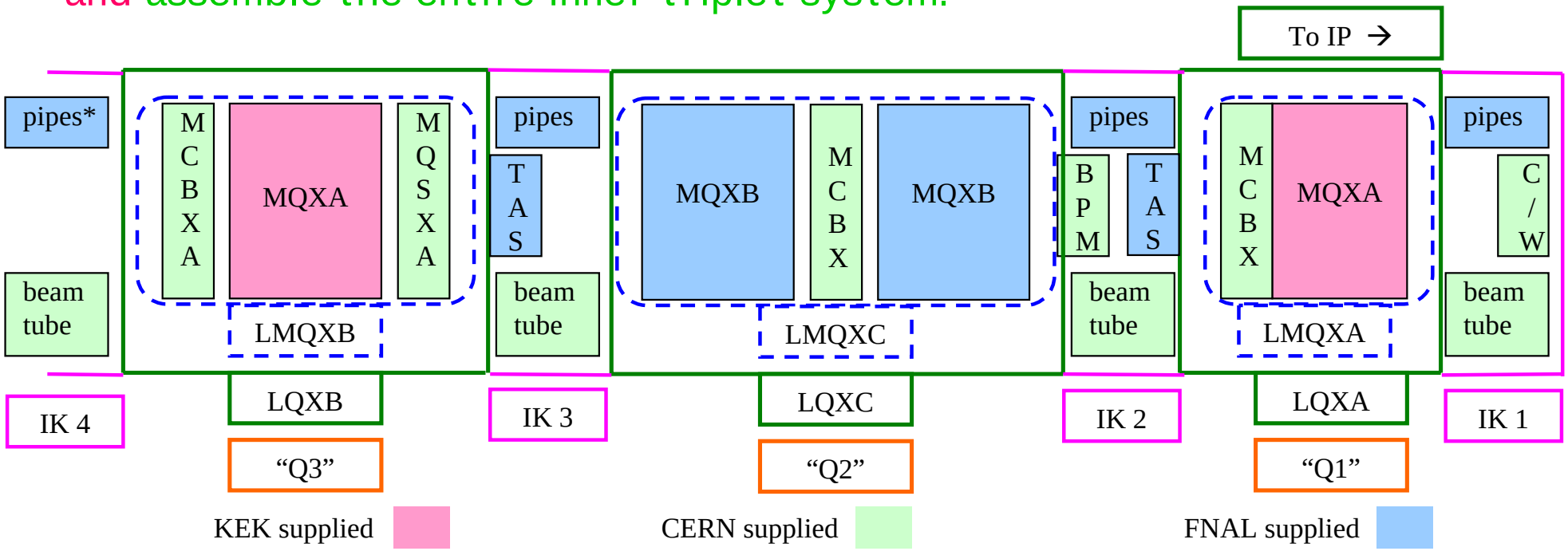
Accelerator physics (all 3 labs)



Project management and oversight (FNAL)

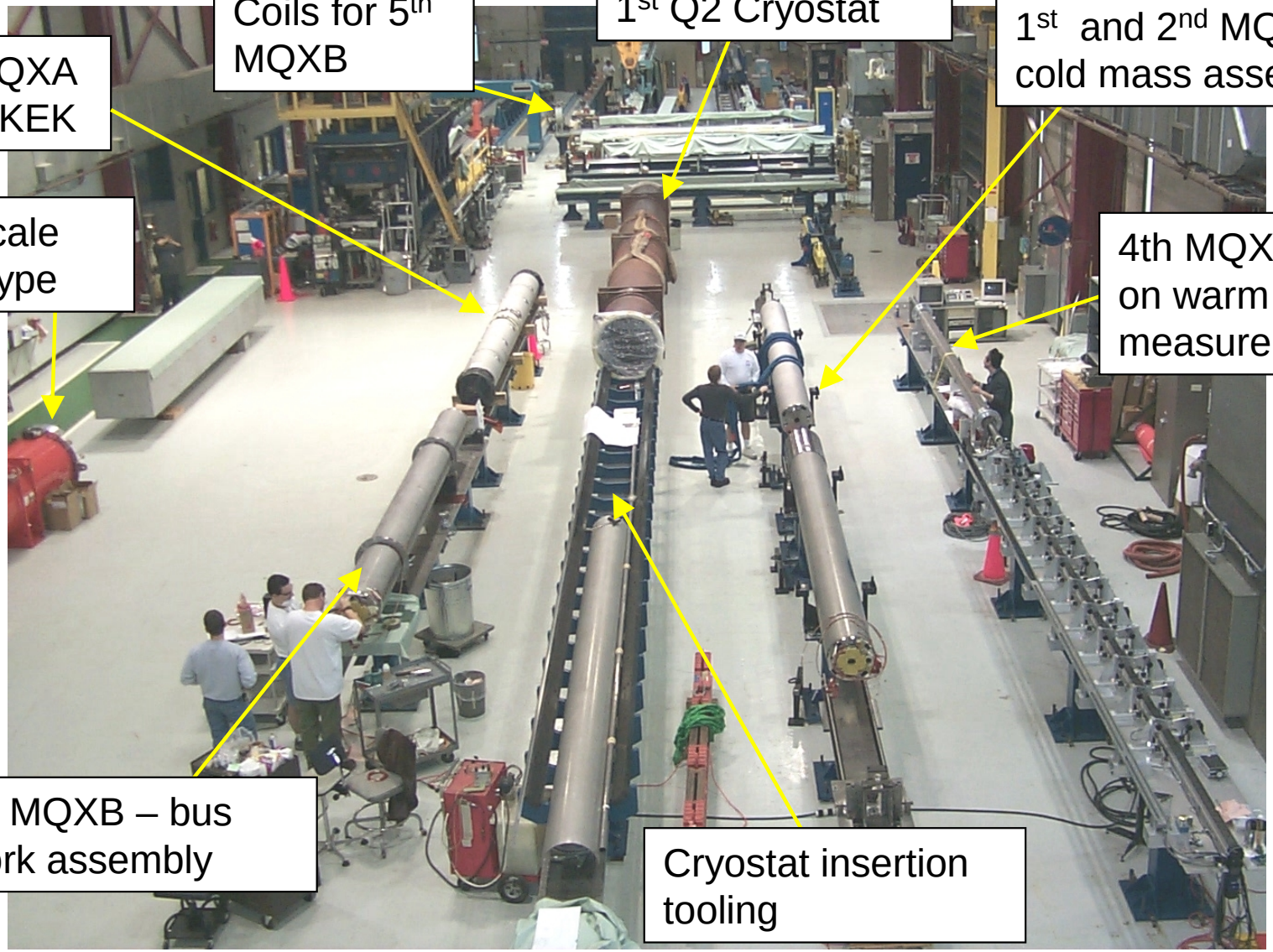
Inner Triplet System

Fermilab is responsible to build the Q2 quadrupoles (MQXB) and assemble the entire inner triplet system.

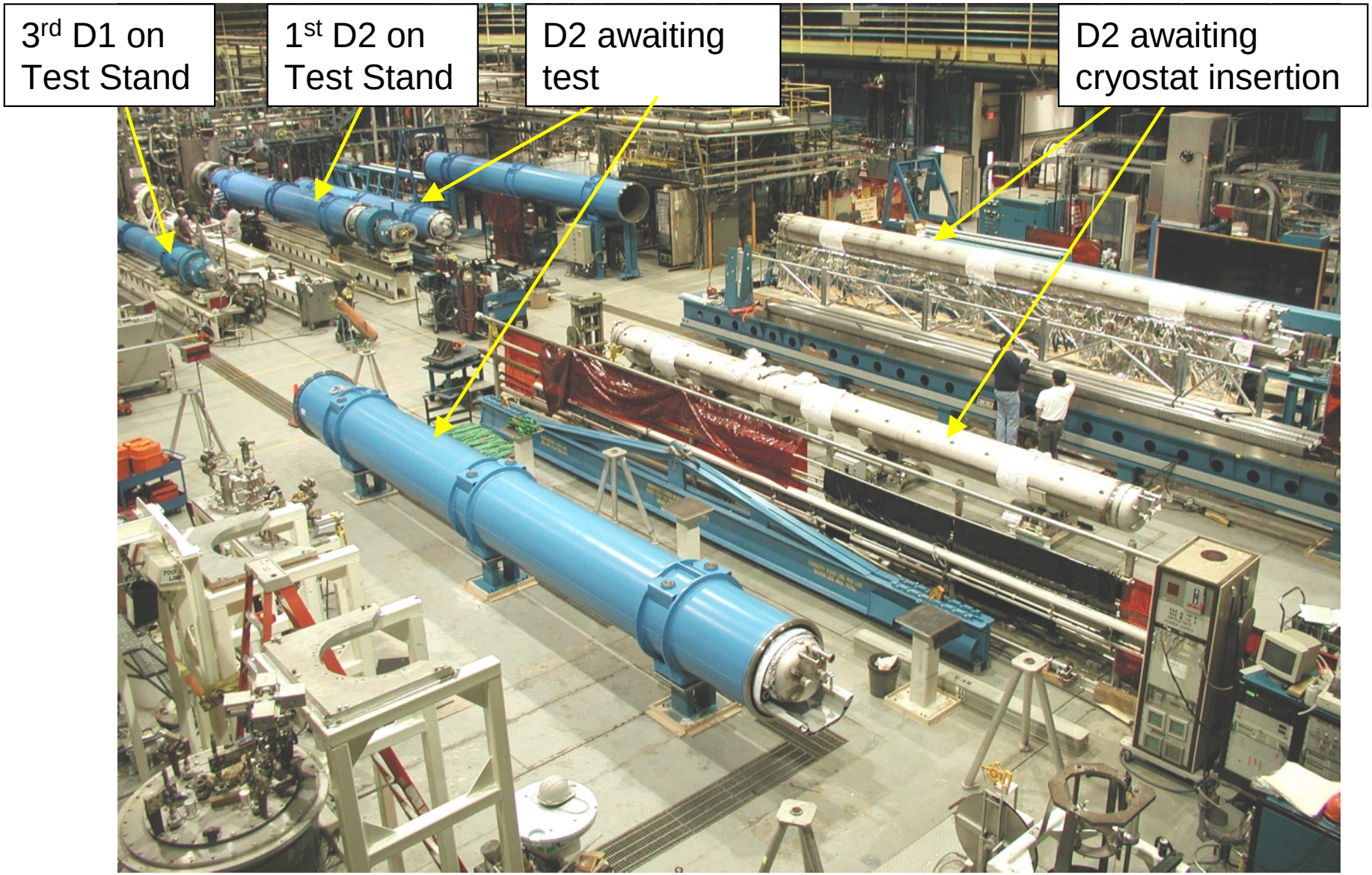


- 18 MQXB (FNAL) required to make 9 Q2 assemblies.
- 18 MQXA (KEK) required to make 9 Q1 and 9 Q3 assemblies.

IR Quadrupole Production at FNAL

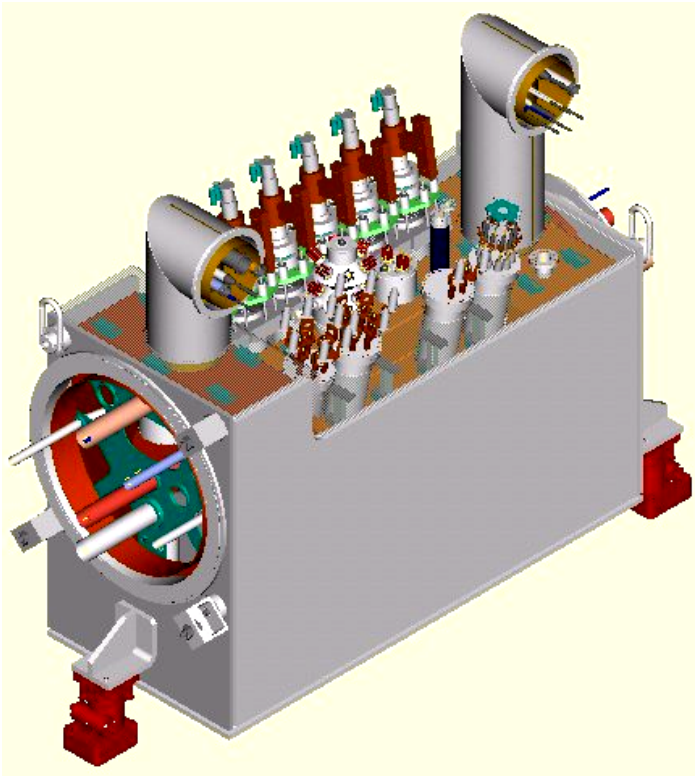


Beam Separation Dipole Production at BNL



IR Feedboxes and IR Absorbers at LBNL

Preparing RFP for Feedbox construction in industry.



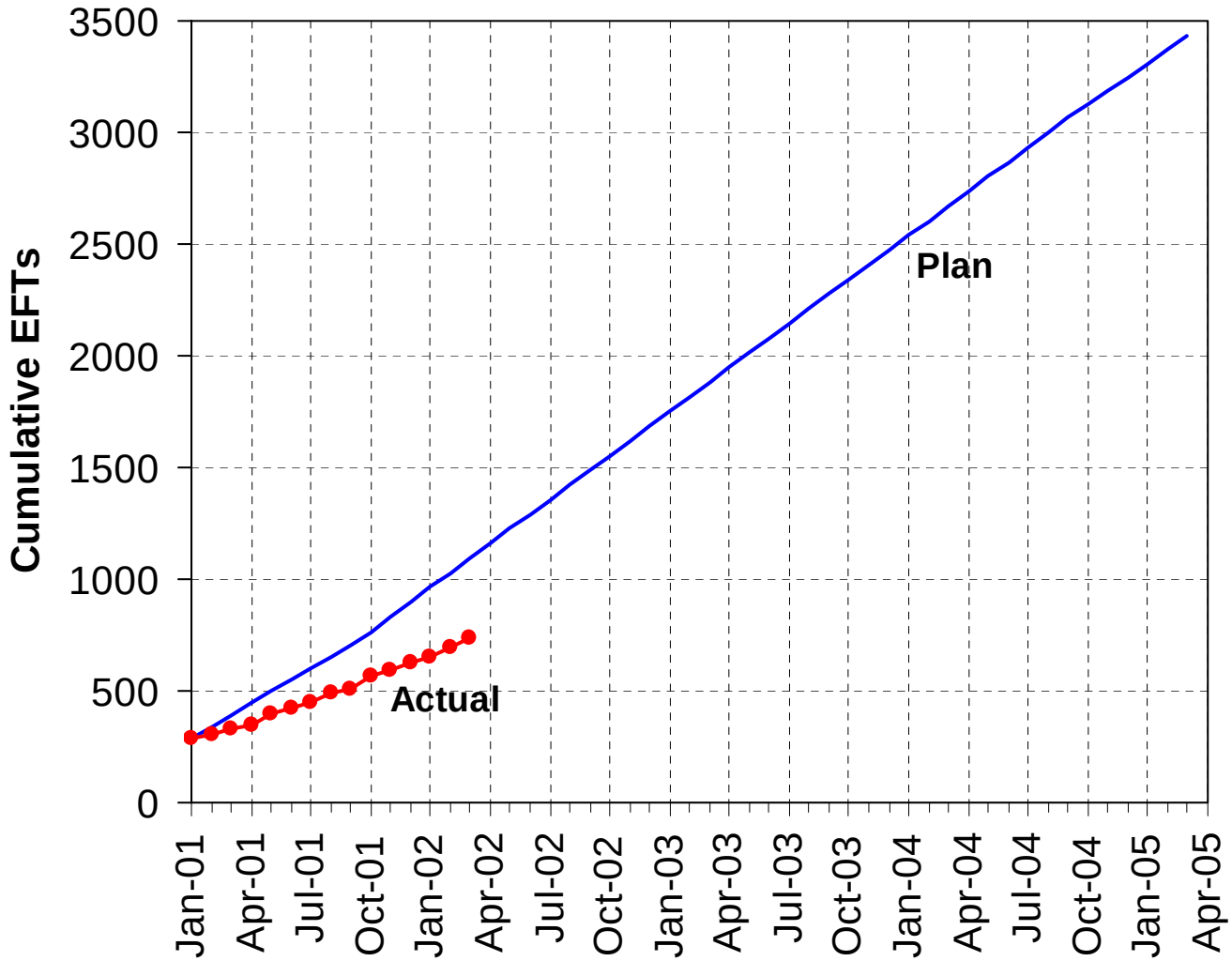
7.5 kA leads built by Pirelli, UK

IR Absorbers in Production

Production SC Cable Testing at BNL

Cable Testing continues to ramp up, but more slowly than planned.

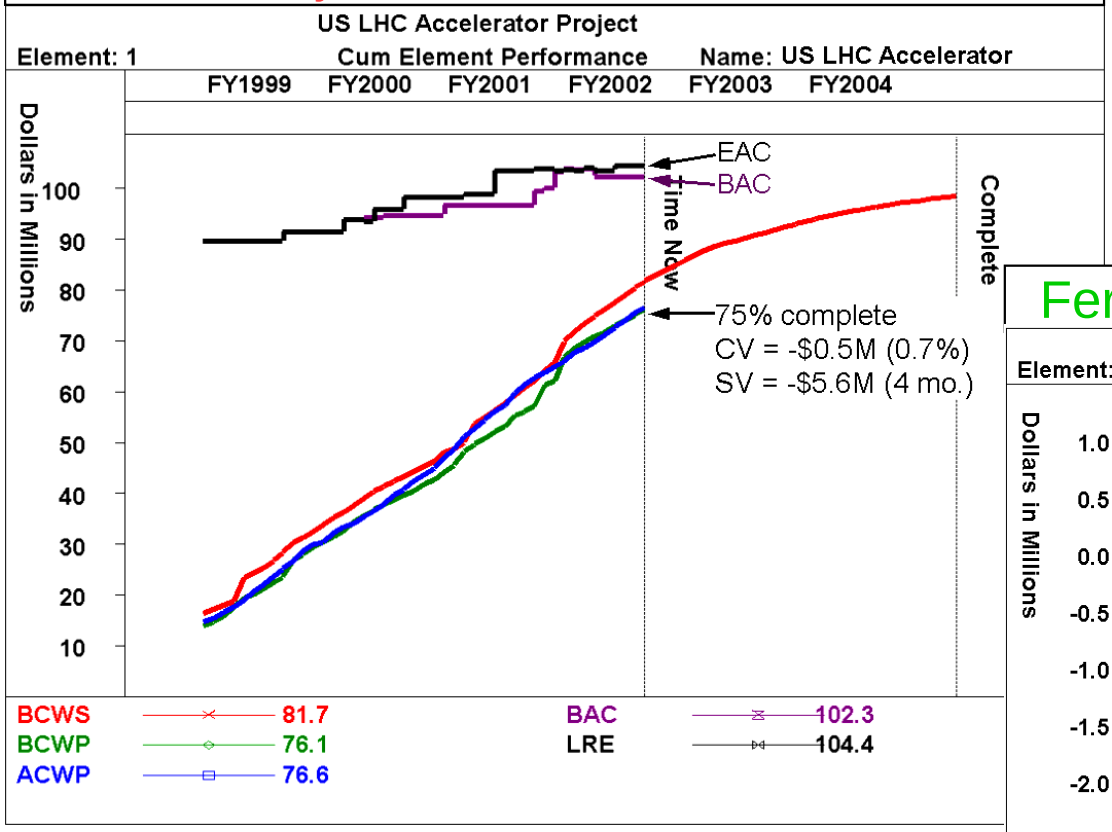
- CERN samples arriving at about 40 per month (~60% of peak rate).
- BNL testing samples as they arrive.



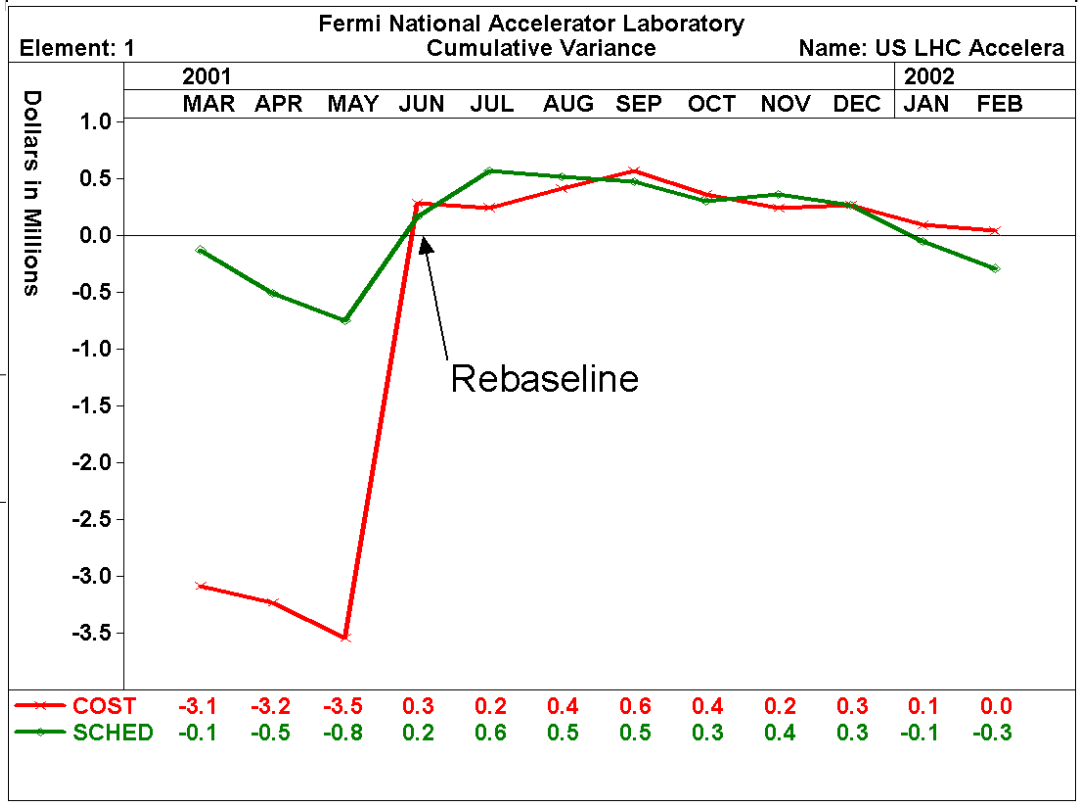
Cost and Schedule Performance

Through February 2002

Whole Project – Cumulative Performance



Fermilab Part – Cost and Sched Variances



US LHC Accelerator Research Program

The US Hadron Accelerator Community and CERN plan to continue the collaboration established for the construction of LHC.

The goals of this program are to

- Extend and improve the performance of the LHC, so as to maximize its scientific output, in support of US-CMS and US-ATLAS.
- Maintain and develop *the US labs' capabilities*, so that the *US can be the leader* in the next generation of hadron colliders.
- Serve as a vehicle for US accelerator specialists *to pursue their research.*
- *Train future generations* of accelerator physicists.
- It is the next step in *international cooperation* on large accelerators.

Fermilab has been appointed the "Host Laboratory" to lead this program.

CERN management strongly supports our continued collaboration.

Planned Activities

Our program is organized in four areas of research:

- Accelerator physics experiments and calculations.
  - Understanding performance limitations of current IRs and developing new designs.
  - Participation in the sector test and machine start-up.
  - Beam dynamics calculations and experiments.
- Developing high performance magnets for new higher luminosity IRs.
  - Large-aperture, high gradient quadrupoles using Nb_3Sn.
  - High-field beam separation dipoles and strong correctors.
- Developing advanced beam diagnostics and instrumentation.
- Commissioning our hardware for the LHC.

Interaction Region Development

- The IRs will be among the limiting systems. Replacement of the existing quads is a necessary route to higher luminosity.
- The existing quadrupoles have a radiation lifetime of 6-7 years at design luminosity, and we must be prepared to replace them by about 2014.
- US-CERN-KEK collaboration meeting on IR upgrade options was held 11-12 March 2002.
  - Second meeting is planned for November 2002.
- Several designs for new IRs have been proposed.
  - Maintain the existing optical layout, but with larger aperture quadrupoles made of Nb_3Sn superconductor.
  - Re-arrange the IR to place a beam separation dipole before the quads, which then become smaller aperture, twin-bore magnets.

US Program on IR Upgrade Magnets

- Goal: Development of technologies and prototypes of superconducting magnets for high-luminosity inner triplets, as part of an upgrade program to raise LHC luminosity $10^{34} \rightarrow 10^{35}$ $cm^{-2}s^{-1}$.
- Program focus is on Nb_3Sn, large-aperture quadrupoles.
  - Builds on and is complementary to "generic" Nb_3Sn dipole R&D programs.
  - Initial program is to develop technologies, not specific designs.
  - Specific design choices will be made after several years of magnet R&D and related accelerator design studies.
- Program also considers development of high-field beam-separation dipoles, required in all IR upgrades scenarios under consideration.
- Large-aperture linear and non-linear correction magnets will have substantially higher pole-tip fields than in the baseline IRs and may become quite challenging.
- *Nature of collaboration with CERN and KEK yet to be established.*

Accelerator Physics

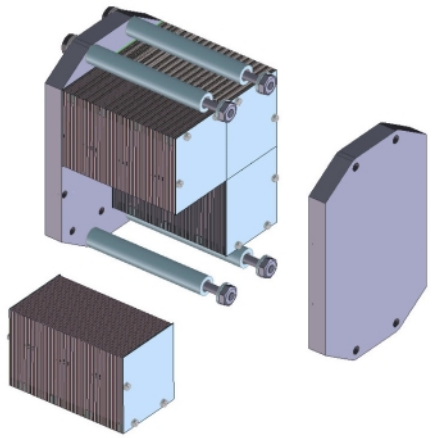
A broad range of accelerator physics activities are planned.

- Interaction Region studies.
  - 2nd generation IR designs.
  - Performance studies for baseline IR.
- Accelerator physics calculations and experiments.
  - Beam-beam interaction studies (calculation and experiment).
  - Electron cloud studies (calculation and experiment).
  - Synchrotron radiation issues in cryogenic environment.
  - Studies of feasibility/applicability of new instrumentation methods.
- Machine development.
  - Machine start-up and commissioning.
  - Ongoing beam studies and machine development.
- LHC-relevant machine studies with RHIC and Tevatron.
- Remote data acquisition and (eventually) control room

Instrumentation and Diagnostics

Development and possible implementation of "2nd generation" diagnostics:

- Luminosity instrumentation to be installed in IR absorbers.
  - Fast, bunch-by-bunch measurement.
  - Feedback signal for keeping beams in collision.
  - R&D started under construction project.
- Longitudinal profile monitor.
  - Conceptual design studies have begun.
- Phase-locked loops for tune and chromaticity control.
  - Based on systems currently being developed for RHIC.



Longer-term ideas, whose feasibility or necessity must be demonstrated.

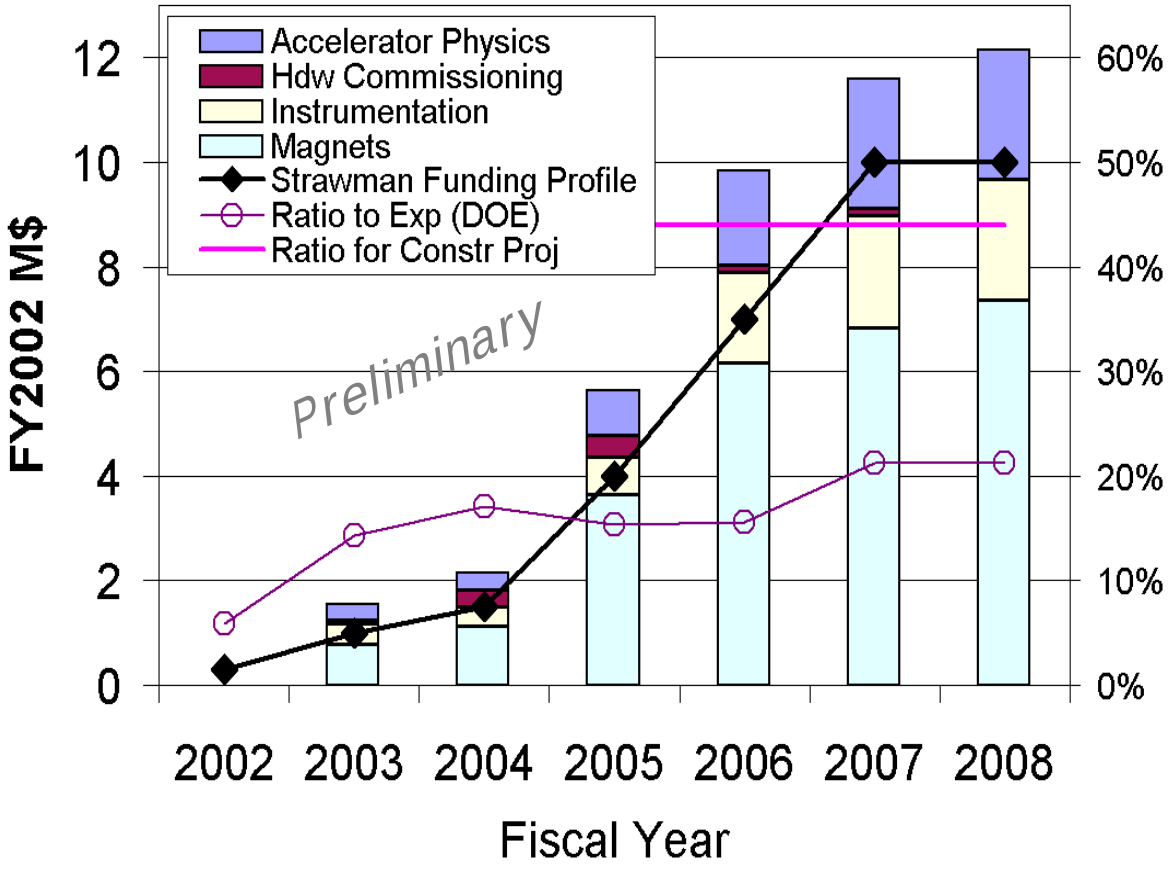
- Electron lens, currently being developed for the Tevatron.
- Bunch-by-bunch closed orbit control and feedback system.
- Other advanced feedback systems, to be developed as ideas emerge or limitations of LHC become known.

Hardware Commissioning

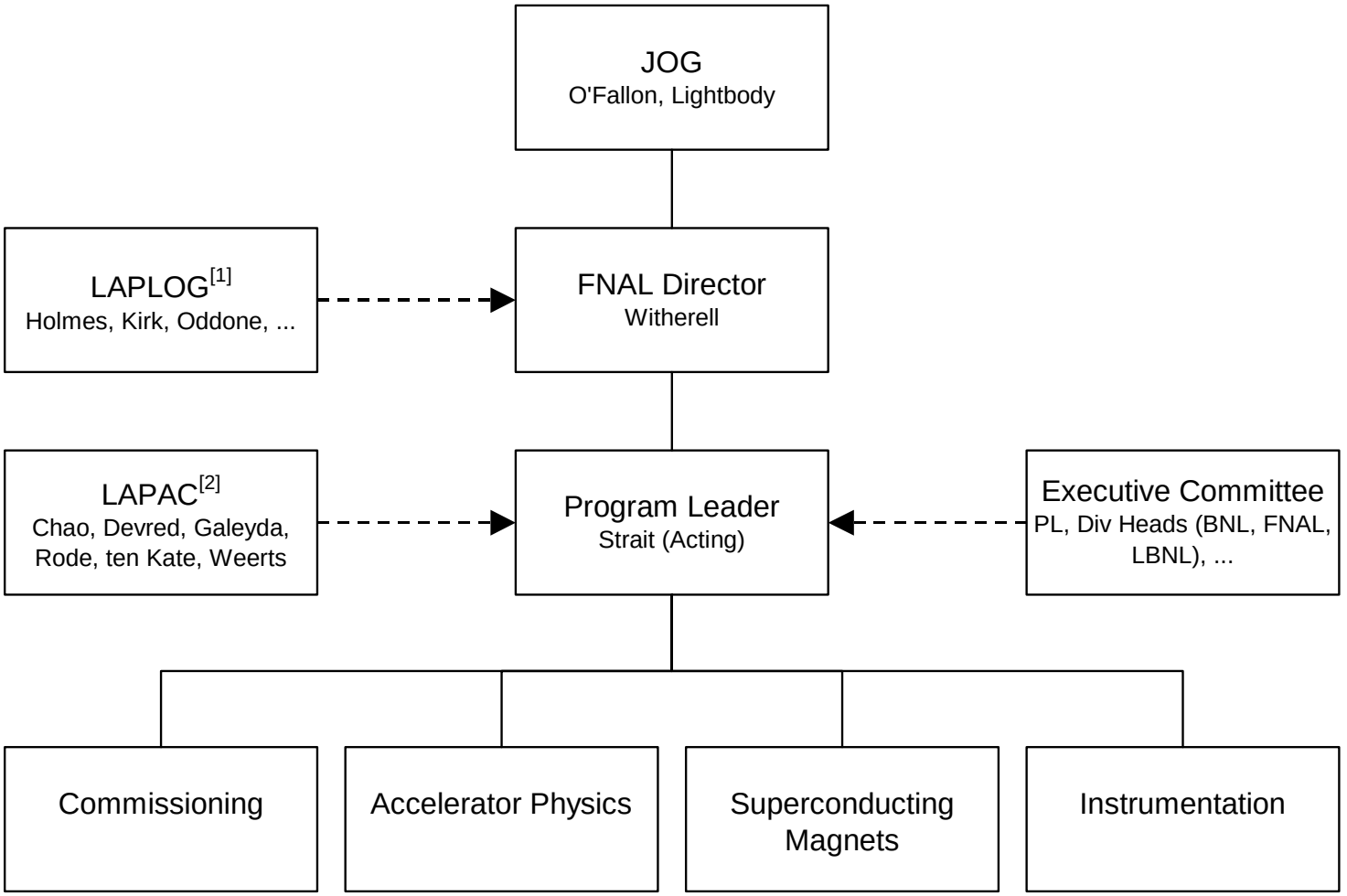
- US responsibility for systems delivered under the present construction project ends when CERN accepts them (2002-2004).
- We plan, as part of the research program, to participate in the commissioning of our equipment in the LHC tunnel.
  - Serve as ‘consultants’ to CERN during installation of our equipment (2004-2006).
  - Full participation in 1st operation of our systems - quads, dipoles, feedboxes, absorbers (2005-2007).
    - Cooldown and powering of magnets.
    - Operation of cryogenic control systems.
    - Quench protection.
    - Vacuum and alignment.
    - First beam operation.

Cost Estimates and Funding

- We are developing cost estimates for all program elements, with a ~5 year time horizon, which we will update yearly.
- The Program is defined by the science and technology to meet the Program goals, and will be carried out based on optimal use of resources at the three labs.
- We lack specific guidance on funding, but have made a reasonable estimate, for planning purposes, based on informal discussions with DOE.



Draft Organization Chart



Program Direction and Reporting

Advice

[1] US LHC Accelerator Program Laboratory Oversight Group

[2] US LHC Accelerator Program Advisory Committee

Conclusions

US LHC Accelerator Project:

- Good technical progress is being made on all sub-projects.
- The Project has adequate float with respect to the CERN schedule. Fermilab part of the LHC project is essentially on schedule.
- Project as a whole, and the Fermilab part of it, are essentially on cost. Contingency, at ~20% of cost to go, is adequate.

US LHC Accelerator Research Program:

- US collaboration on the LHC accelerator is an essential component of the US HEP program.
  - Supports CMS and ATLAS by improving LHC performance.
  - Advances our capabilities in accelerator physics and technology.
- Program planning leading to a Lehman Review in June is well along.
- The participants at all 3 labs have agreed on the scientific program and management approach.